

WHITE PAPER

Arcadis:

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October 29, 2018

HOMESTAKE MINING COMPANY OF CALIFORNIA

Grants Reclamation Project



Evaluation of Water Quality in Regard to Site Background
Standards at the Grants Reclamation Project

September 2018

Meeting Agenda

- Introductions, safety share
- Meeting Objectives
- Overview of White Paper

Seasonal slips, trips, and falls

Wet leaves

- Reduce traction while walking, biking, and driving

Dry leaves

- Reduce traction
- Obscure walking/biking/driving surface

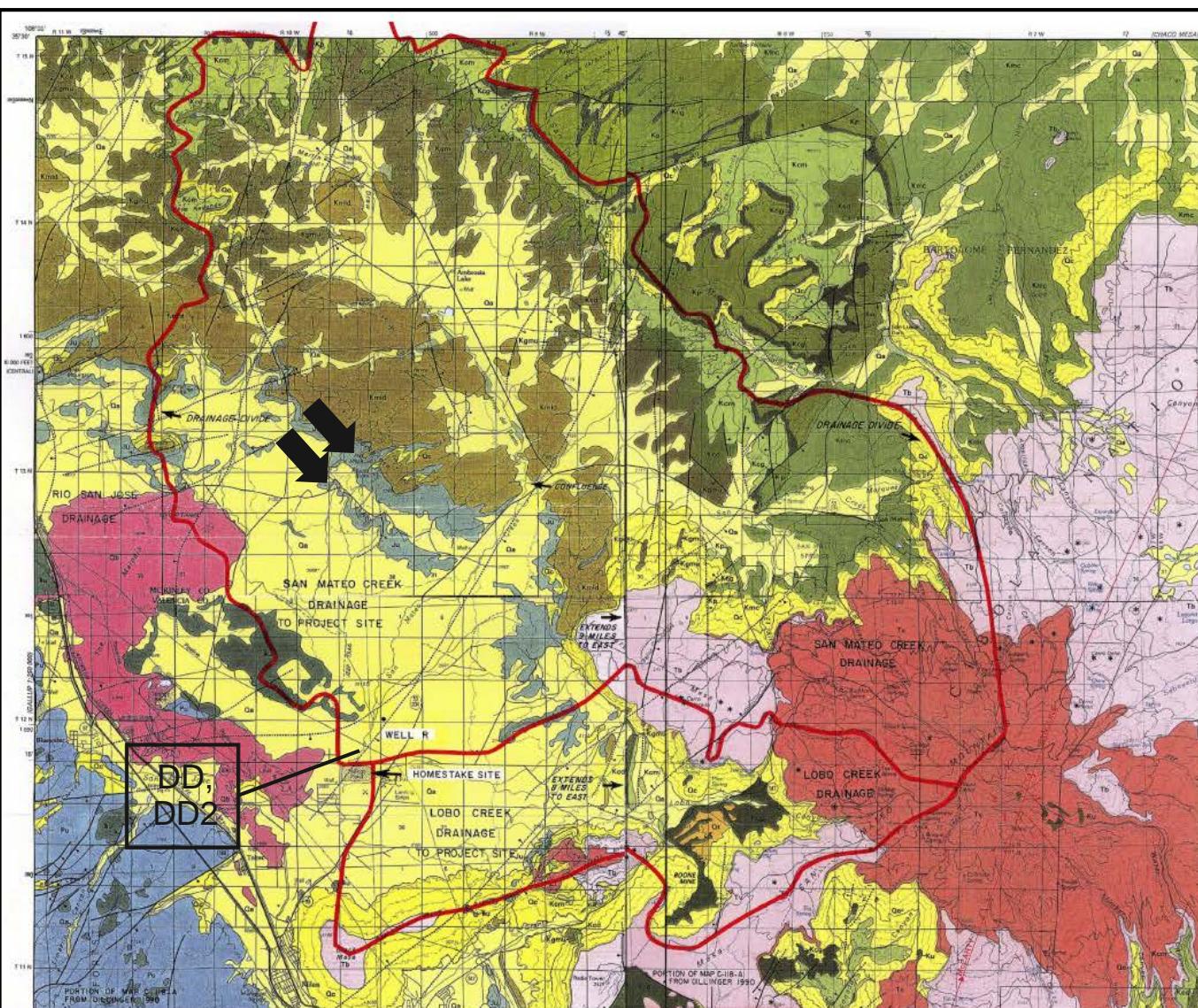


HMC Grants Mill site

San Mateo Creek Basin Geology



Design & Consultancy
for natural and
built assets



Source:
Dillinger, J.K., 1990, Geologic map of the Grants 30' x 60' quadrangle, west-central New Mexico: U.S. Geological Survey, Coal Investigation Map C-118-A, scale 1:100,000.

GRANTS RECLAMATION PROJECT
Updated Corrective Action Program (CAP)

FIGURE 3.1-1
BEDROCK GEOLOGY

San Mateo Creek Basin Geology



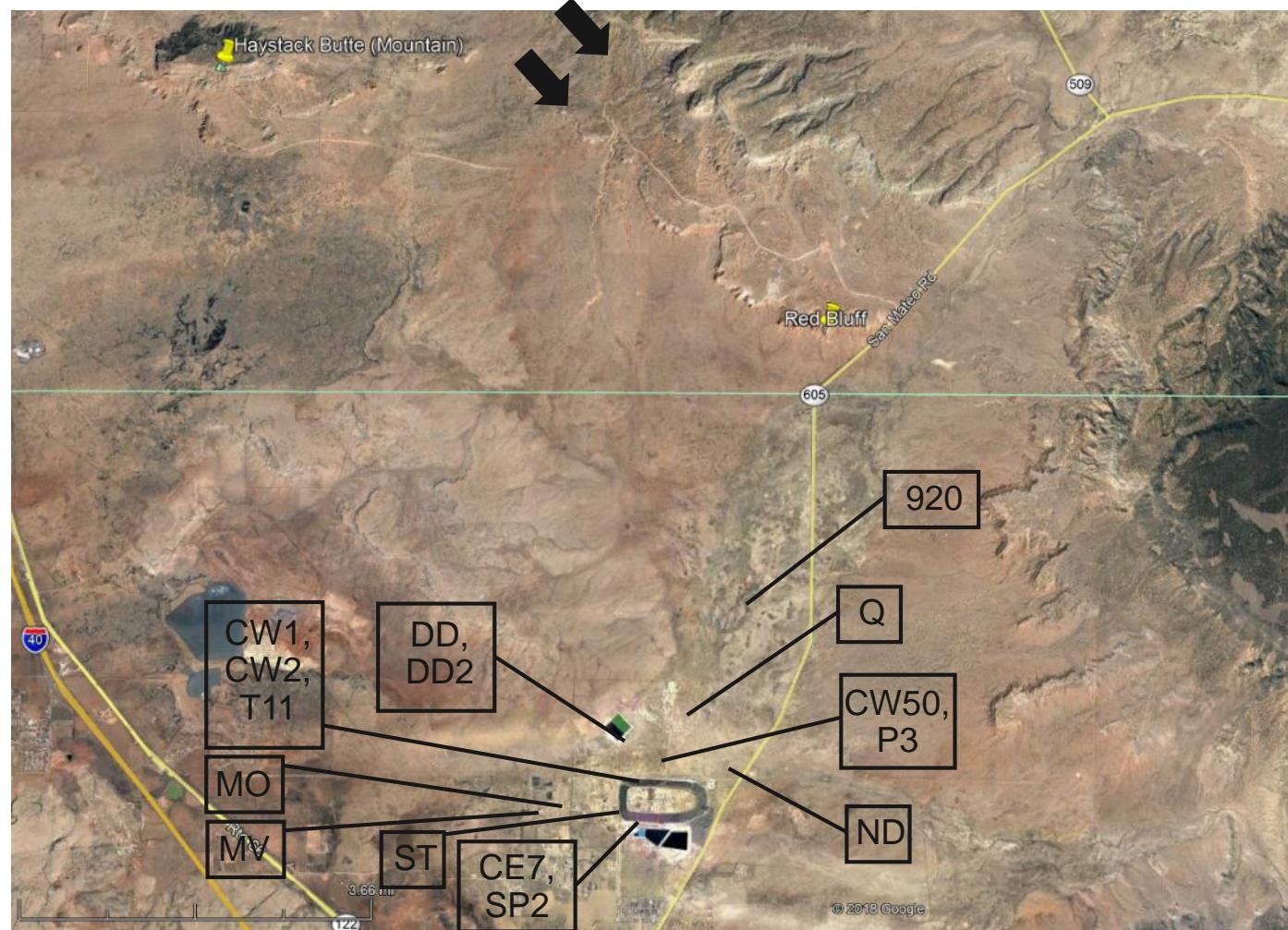
Design & Consultancy
for natural and
built assets

Alluvium is from
eroded highlands

This rock contains
ore-grade uranium

Results in
disseminated
uranium-
containing
particles in
alluvium

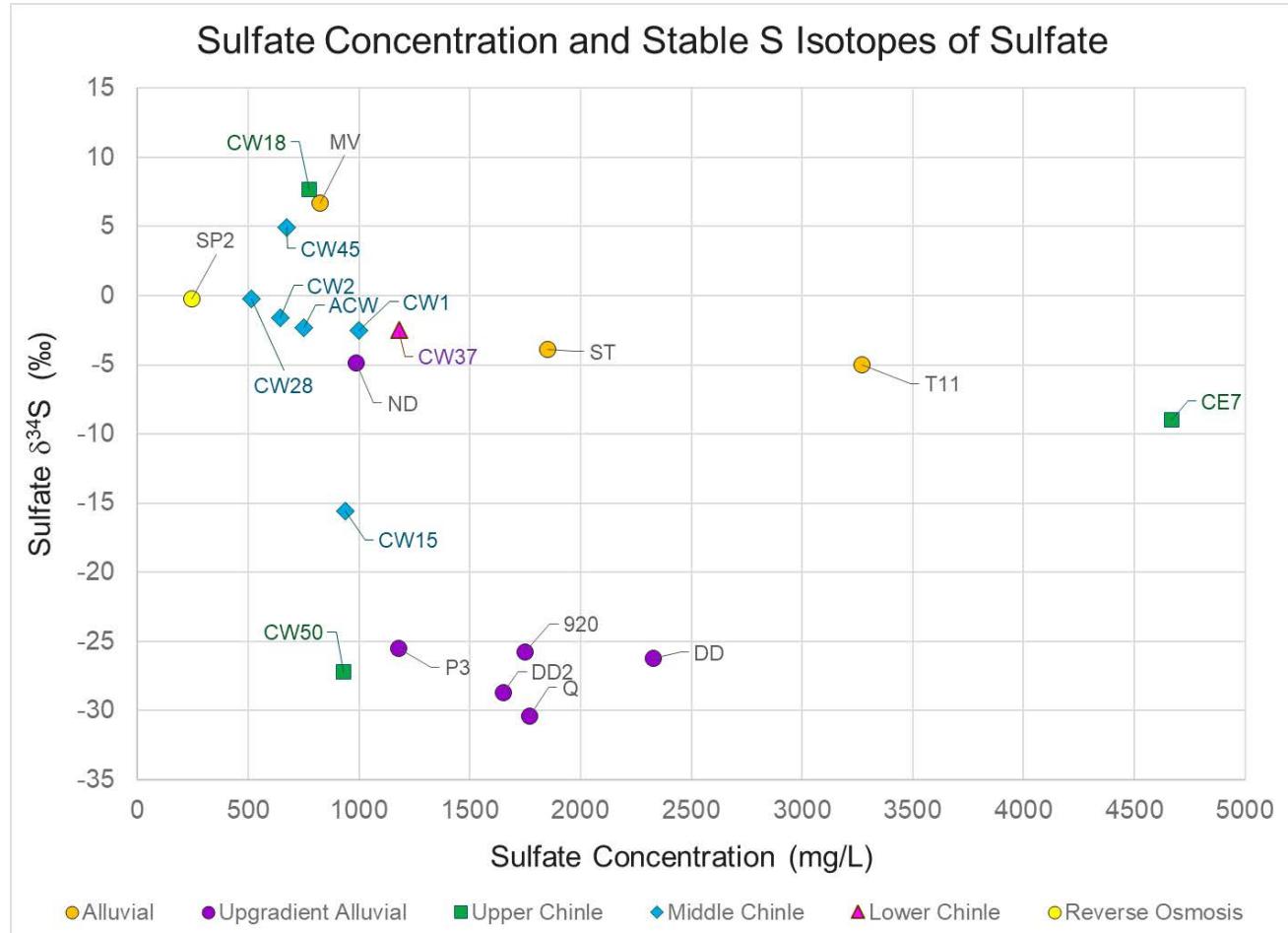
Erosion/fluvial
deposition is a
heterogeneous
process (visible)



Split sampling event: Summer 2016

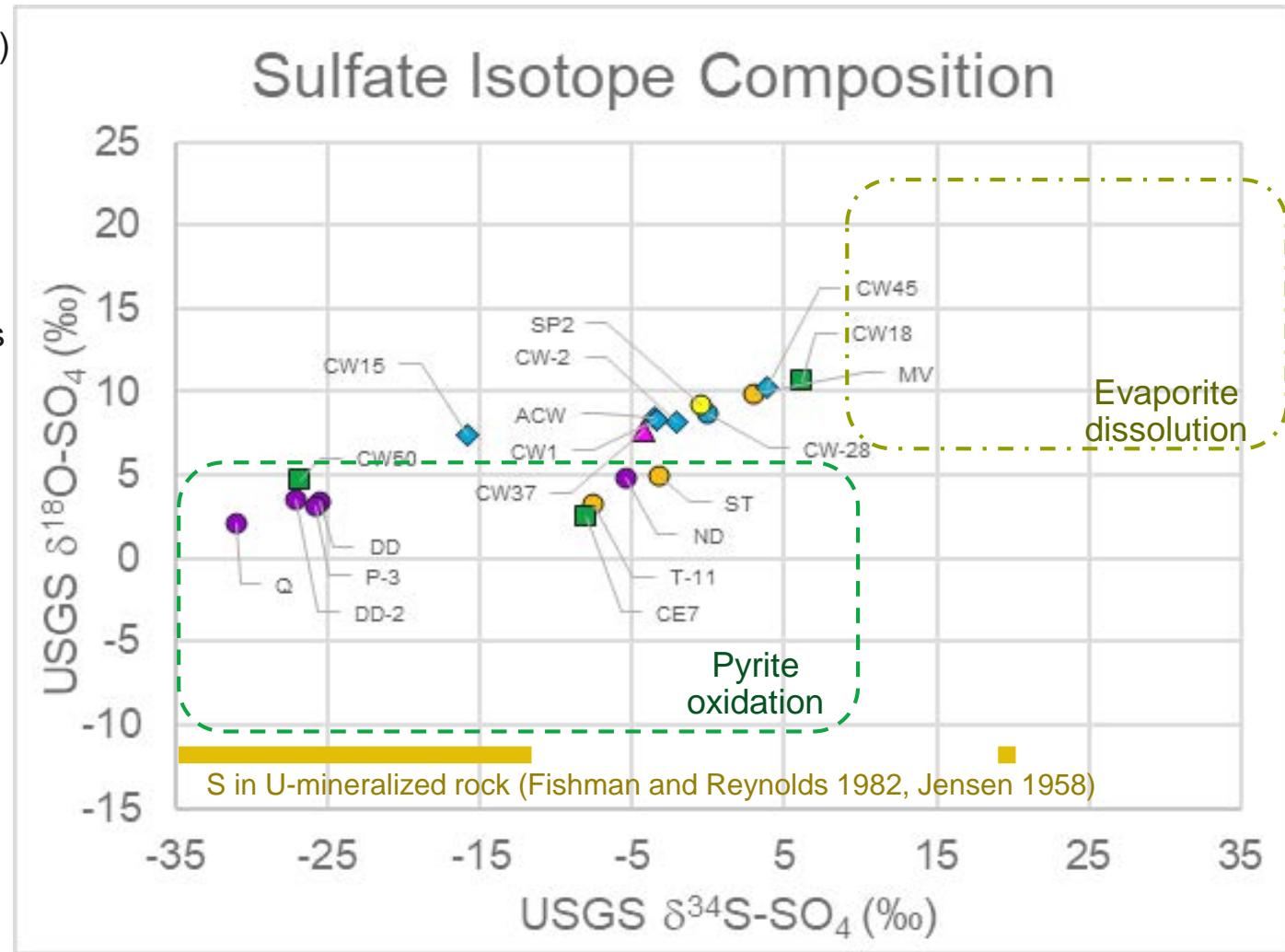
Sulfate S and O Isotopes

- Stable sulfur isotopes suggest pyrite oxidation is primary sulfate source.
- Samples with lower sulfate concentrations and more positive $\delta^{34}\text{S}$ values suggest sulfate derived from combination of pyrite oxidation and gypsum dissolution.
- Use of sulfuric acid in U ore processing ($\delta^{34}\text{S} \sim -8$ to $32\text{\textperthousand}$) may account for the higher sulfate concentration and heavier isotope signature from mills/tailings



Sulfate S and O Isotopes

- Region contains naturally-occurring sulfide minerals (pyrite) in U-mineralized rocks and U-mineralized sediment present in alluvial aquifer
- Oxidation of S from sulfide minerals results in sulfate formation
- The greatest negative signatures come from areas that experience cycles of sulfide formation/oxidation



Massive collection of iron oxide pseudomorphs of pyrite framboids

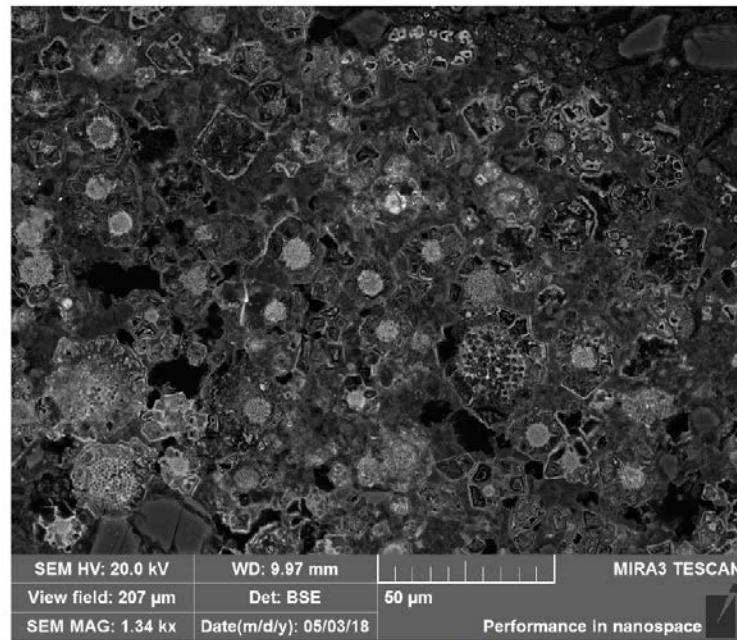
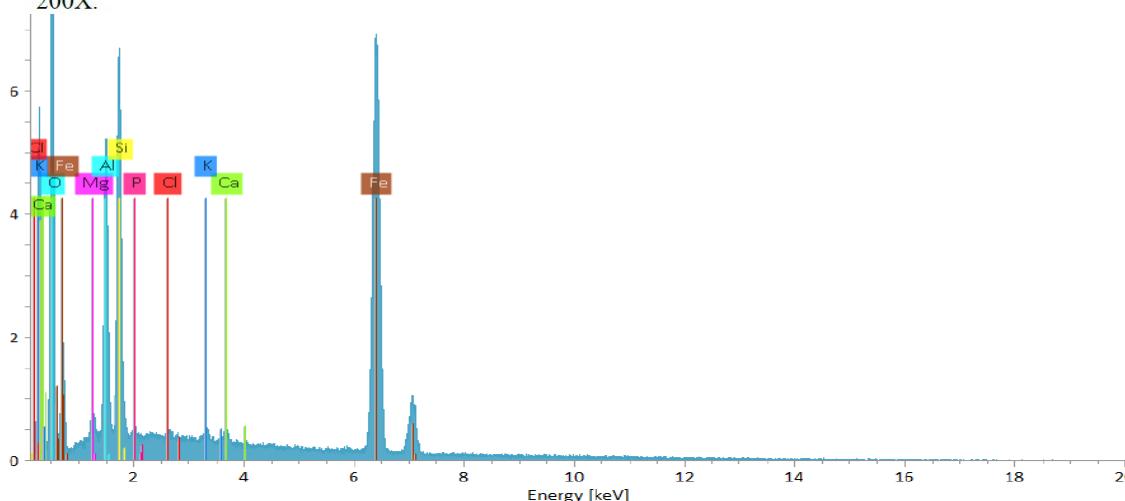


Client Sample No.: DD2-BK-25-26-012218

Iron oxide pseudomorphs after pyrite and pyrite framboids. Reflected light crossed Nichols – Backscatter image of iron oxide pseudomorphs after pyrite cubes and framboids – 1,340X.

200X.

- Unsaturated zone
- Massive/lithic



Client Sample No.: DD2-BK-25-26-012218

SEM HV: 20.0 kV

WD: 9.97 mm

View field:

Det: BSE

SEM MAG:

50 μm

1.34 kx

Date(m/d/y): 05/03/18

MIRA3 TESCAN

Performance in nanospace

Notes

μm – microns
BSE – backscatter electron detector
cps/eV – count per second per electron volt
HV – high voltage
keV – kiloelectronvolt
kx – thousand times magnification
KV – kilovolts
m/d/y – month/day/year
mm – millimeters
WD – working distance
X – times magnified

Soil chemistry, mineralogy, and geophysics at DD-BK and DD2-BK

Location of boreholes



- Previous logging by driller, not geologist, with a mud rotary rig
 - Poor sample quality, very little sample visibility, low-resolution core-logging
- This event = high resolution logging, sonic rig
- Revised cross section for this area
- Alternating sands/silts/clays over shale
- Consistent with fluvial deposition of eroded grains from nearby source
- Sub-angular to sub-rounded grains: sediments transported, but not very far

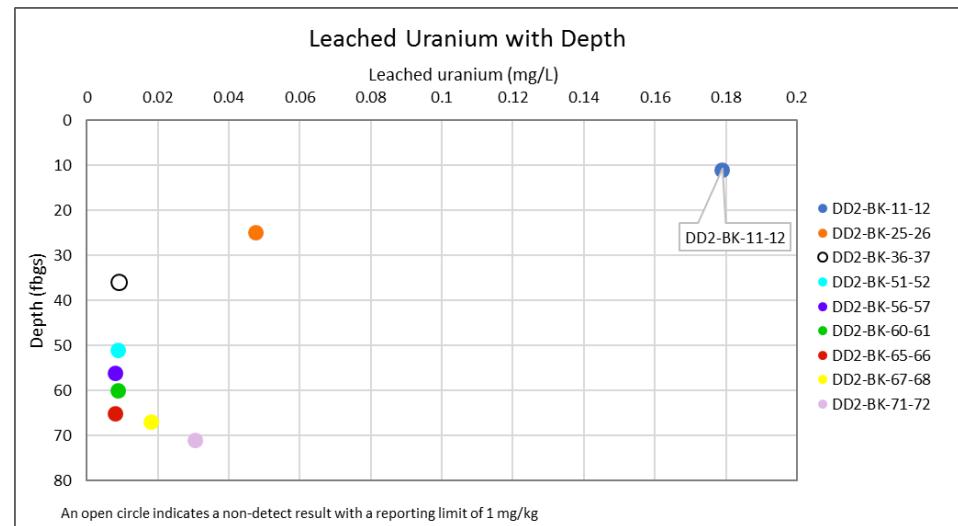
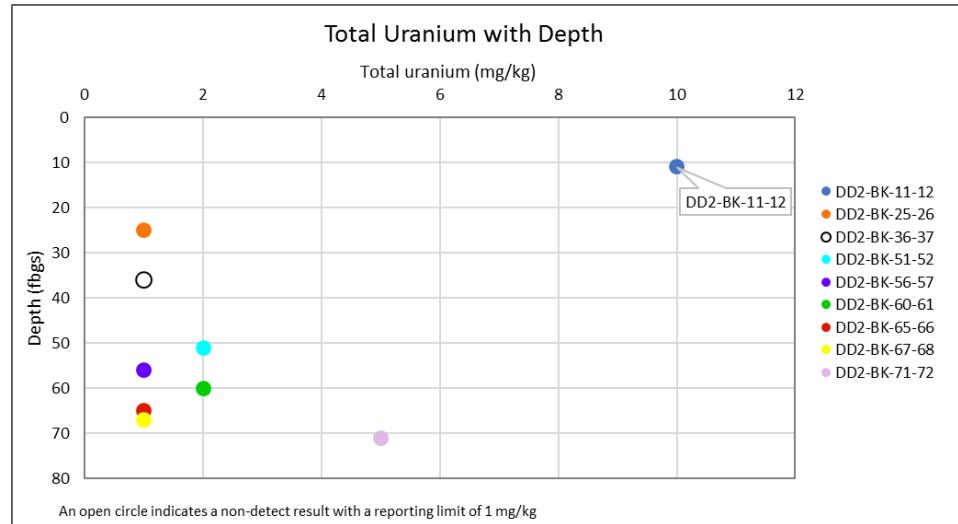
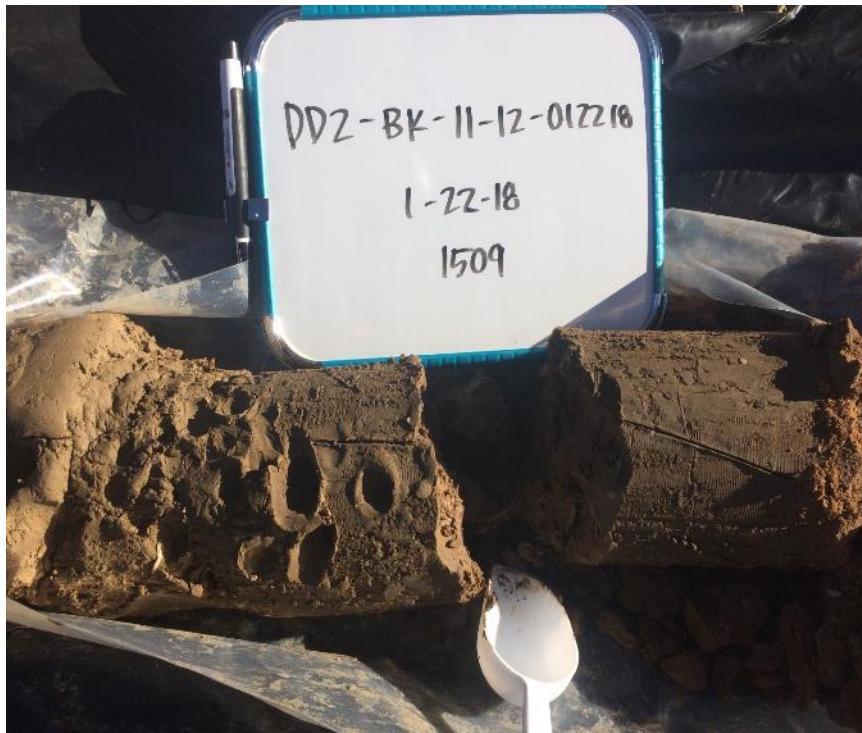
Samples with elevated uranium

Sample ID	Alluvium zone	Total uranium concentration (mg/kg)	Alkaline SPLP leached uranium (mg/L)	Field-logged lithology	ACZ Particle Size Analysis Lithology	DCM analysis
DD2-BK-11-12-012218	unsaturated	10	0.179	CLAY	Clay	Yes
DD2-BK-71-72-012318	saturated	5	0.0305	Gravely SAND with silt	Sand	Yes
DD2-BK-51-52-012318	saturated	2	0.0086	Silty SAND	—	Yes
DD2-BK-60-61-012618	saturated	2	0.0086	CLAY with trace sand	—	Yes
DD2-BK-25-26-012218	unsaturated	1	0.0477	SAND with trace silt	Sand	Yes
DD2-BK-56-57-012318	saturated	1	0.0079	Silty SAND	—	No
DD2-BK-65-66-012318	saturated	1	0.0080	Sandy SILT	—	No
DD2-BK-67-68-012618	saturated	1	0.0180	CLAY	—	No
DD-BK-36-37-012518	unsaturated	1	0.0127	CLAY	Clay	Yes
DD-BK-58-59-012618	saturated	1	0.0032	CLAY	—	Yes
DD-BK-9-10-012518	unsaturated	1	0.0022	CLAY with trace sand	Clay	Yes

19 samples (excluding duplicate) were analyzed by ELI, only those with detectable total uranium concentrations are shown in the table

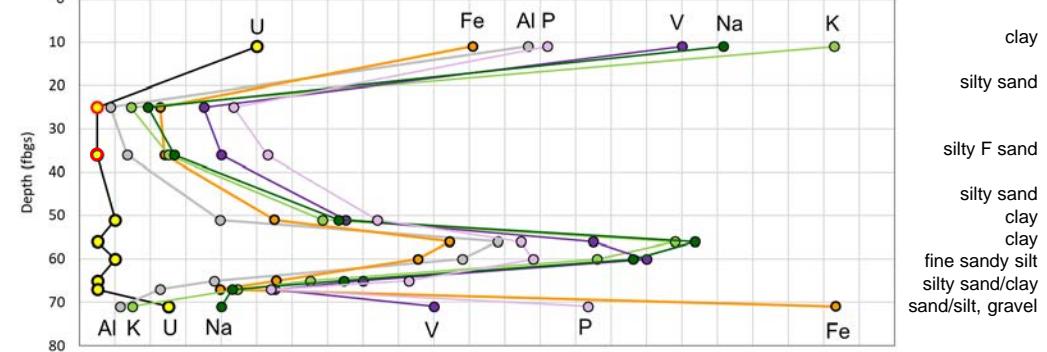
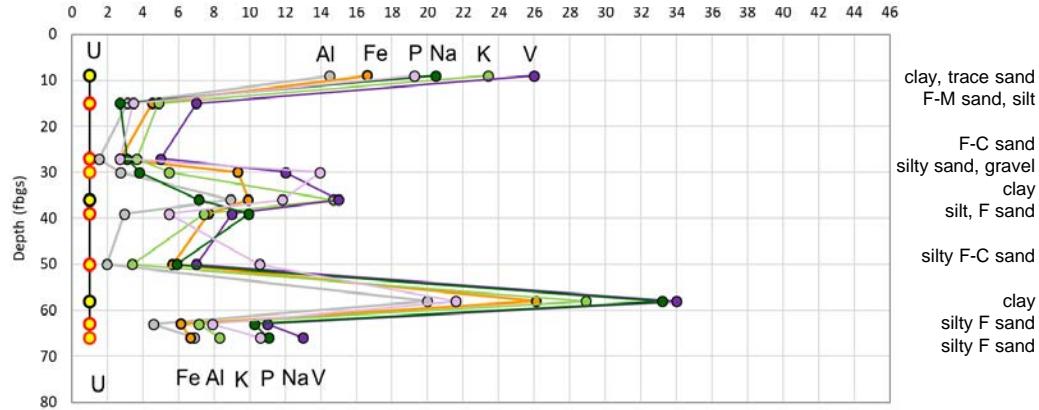
DD2-BK-11-12-012218

- Total uranium concentration: 10 mg/kg
- Alkaline SPLP leached uranium: 0.179 mg/L
- Lithology: Clay



Soil chemistry – total metals

Total metals/metalloids (mg/kg)

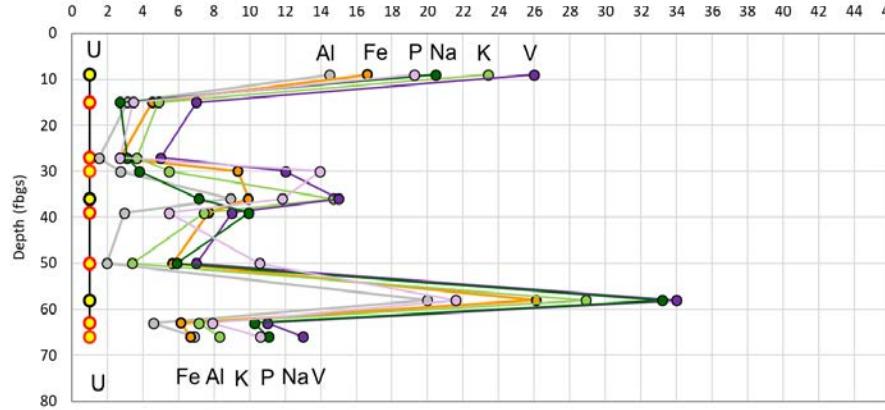


Red circle = non-detect; reporting limit shown
Total Al and Fe/1000; K/100; Na/20

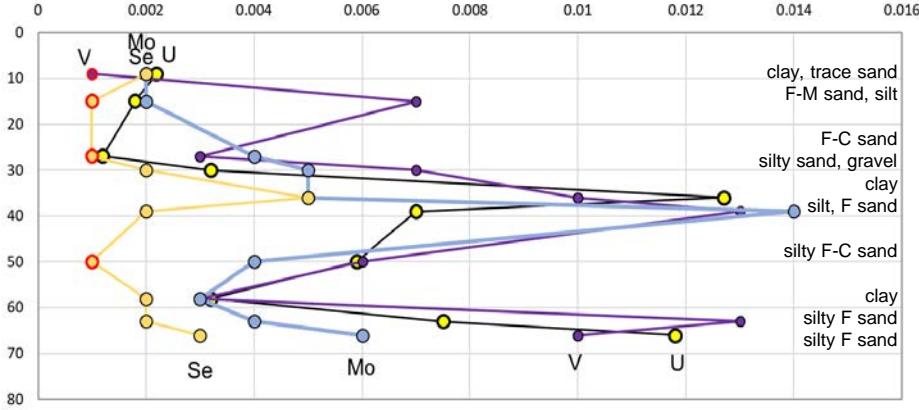
Soil chemistry – total metals and leaching

Leached in an alkaline (simulated groundwater) extraction

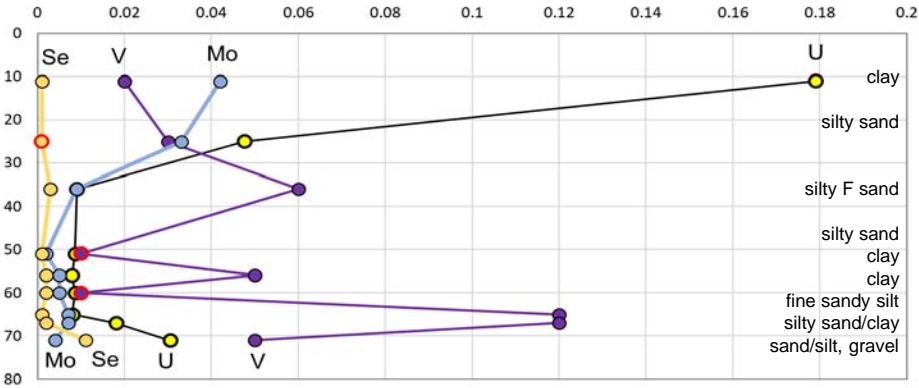
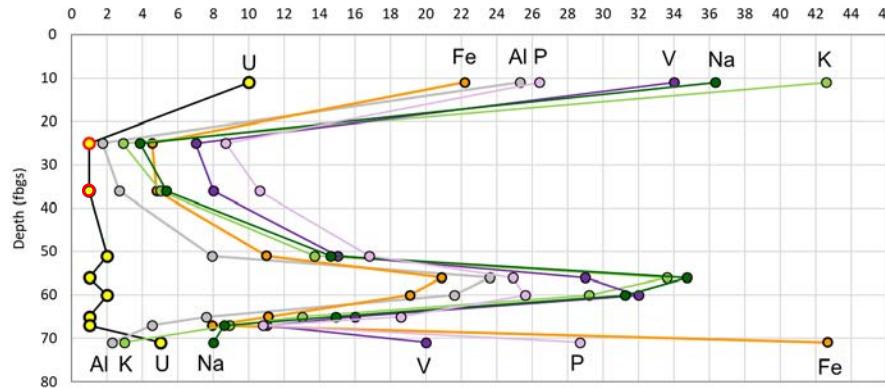
Total metals/metalloids (mg/kg)



Leached metals/metalloids (mg/L)



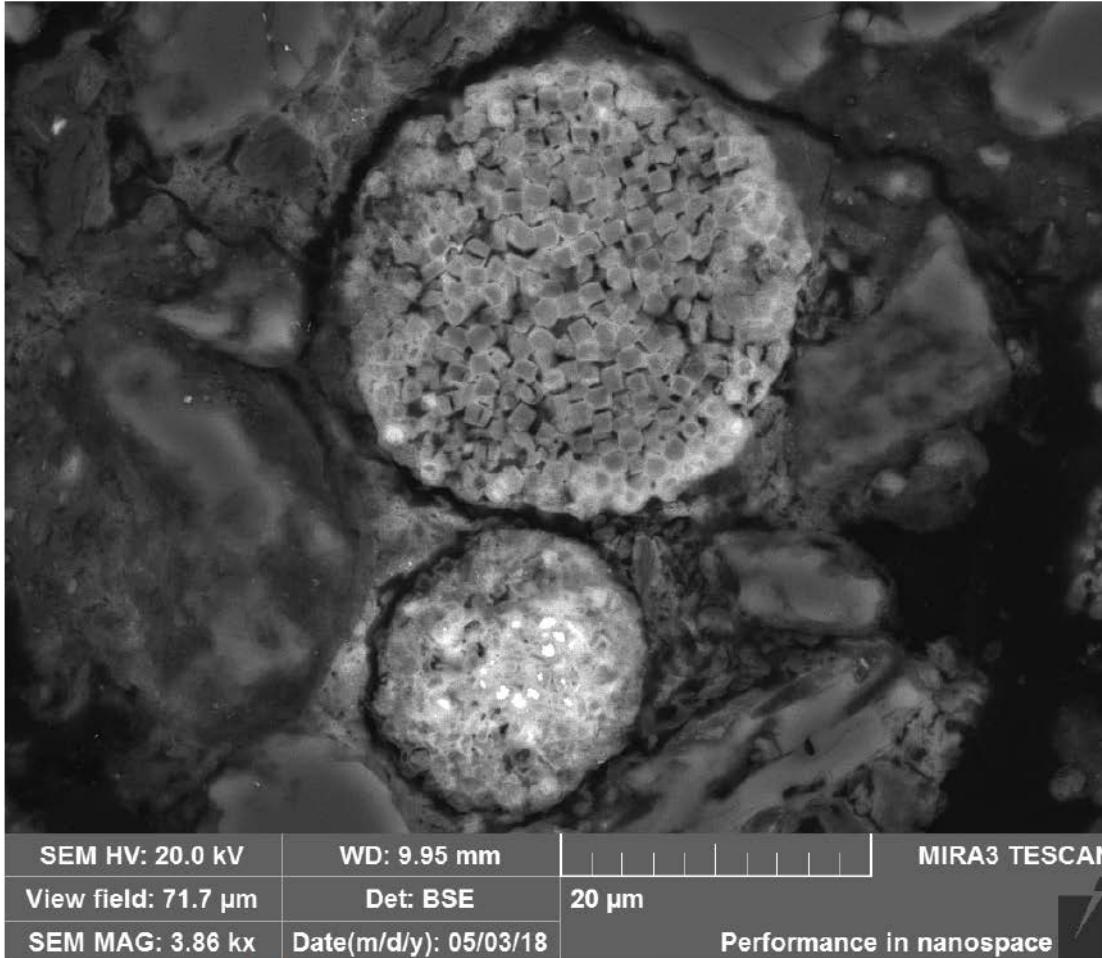
DD-BK



DD2-BK

Red circle = non-detect; reporting limit shown
Total Al and Fe/1000; K/100; Na, P/20

Iron oxide pseudomorphs of pyrite framboids



Client Sample No.: **DD2-BK-51-52-012318**

Backscatter image of iron oxide pseudomorphs after pyrite framboids sit in a matrix of clay with quartz/feldspar grains. The smaller pseudomorph contains bright relict pyrite – 3,860X.

Massive collection of iron oxide pseudomorphs of pyrite framboids

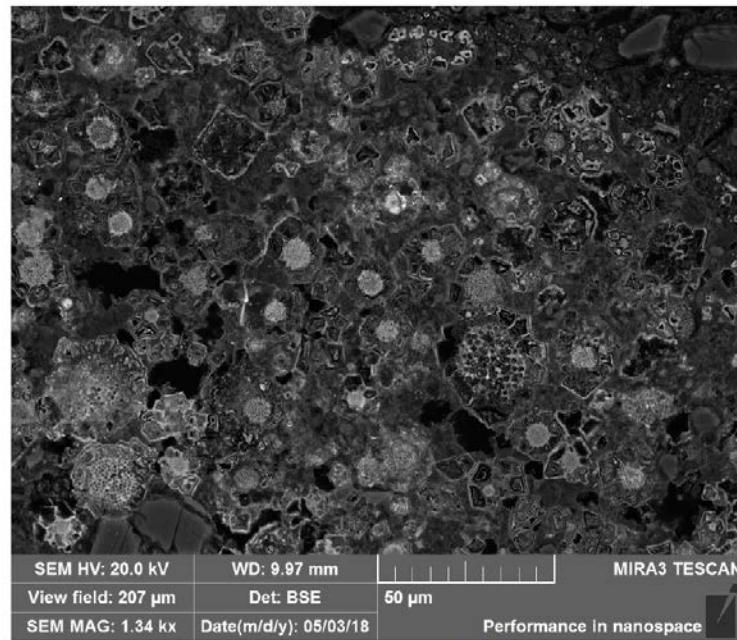
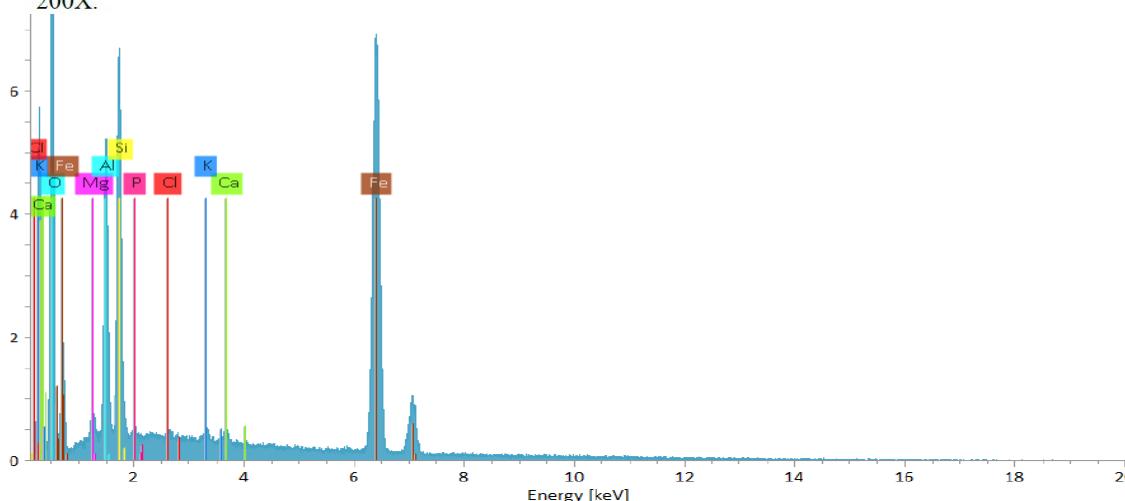


Client Sample No.: DD2-BK-25-26-012218

Iron oxide pseudomorphs after pyrite and pyrite framboids. Reflected light crossed Nichols – Backscatter image of iron oxide pseudomorphs after pyrite cubes and framboids – 1,340X.

200X.

- Unsaturated zone
- Massive/lithic



Client Sample No.: DD2-BK-25-26-012218

SEM HV: 20.0 kV

WD: 9.97 mm

View field: 207 μm

Det: BSE

50 μm

SEM MAG: 1.34 kx

Date(m/d/y): 05/03/18

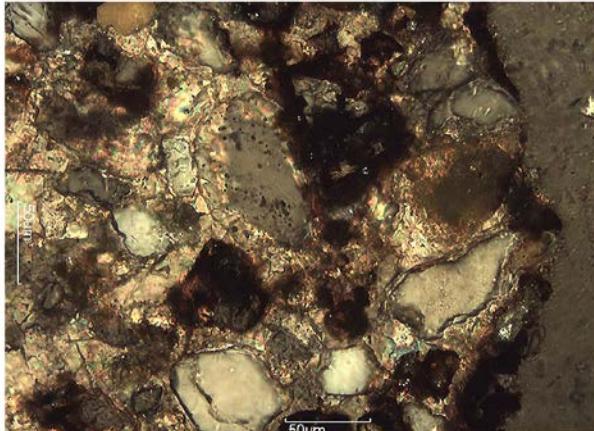
MIRA3 TESCAN

Performance in nanospace

Notes

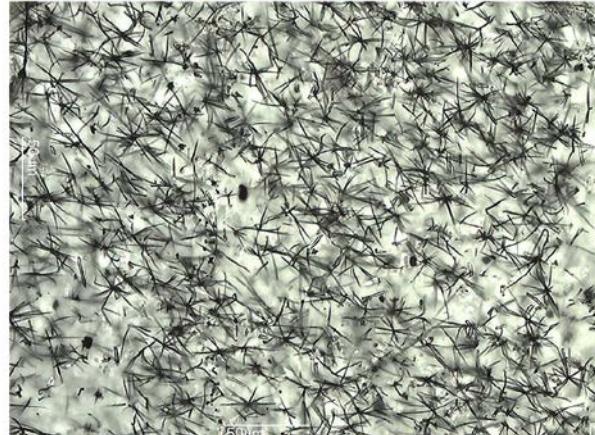
μm – microns
BSE – backscatter electron detector
cps/eV – count per second per electron volt
HV – high voltage
keV – kiloelectronvolt
kx – thousand times magnification
KV – kilovolts
m/d/y – month/day/year
mm – millimeters
WD – working distance
X – times magnified

Mineralogical consortia showing quartz, feldspar, and other igneous mineralogy



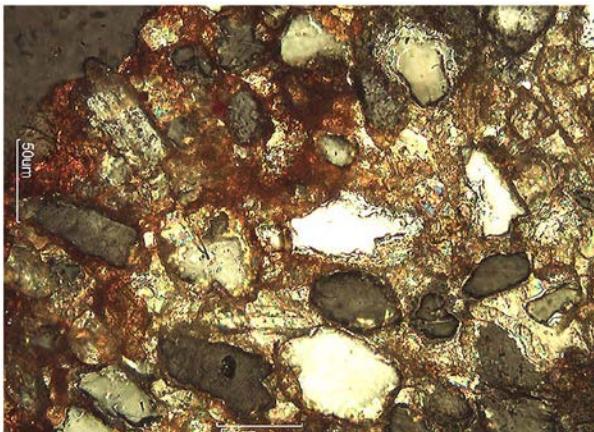
Client Sample No.: **DD2-BK-25-26-012218**

Calcite and iron oxide cement quartz/feldspar grains. Reflected light crossed Nichols – 200X.



Client Sample No. **DD2-BK-25-26-012218**

Fragment of basalt showing unknown opaque, acicular crystallites. Polarized light – 250X.



Client Sample No.: **DD2-BK-71-72-012318**

Calcite and iron oxide cement quartz/feldspar grains. Reflected light crossed Nichols – 200X.



Client Sample No. **DD2-BK-71-72-012318**

Fragment of basalt showing lath shaped plagioclase. Polarized light – 200X.

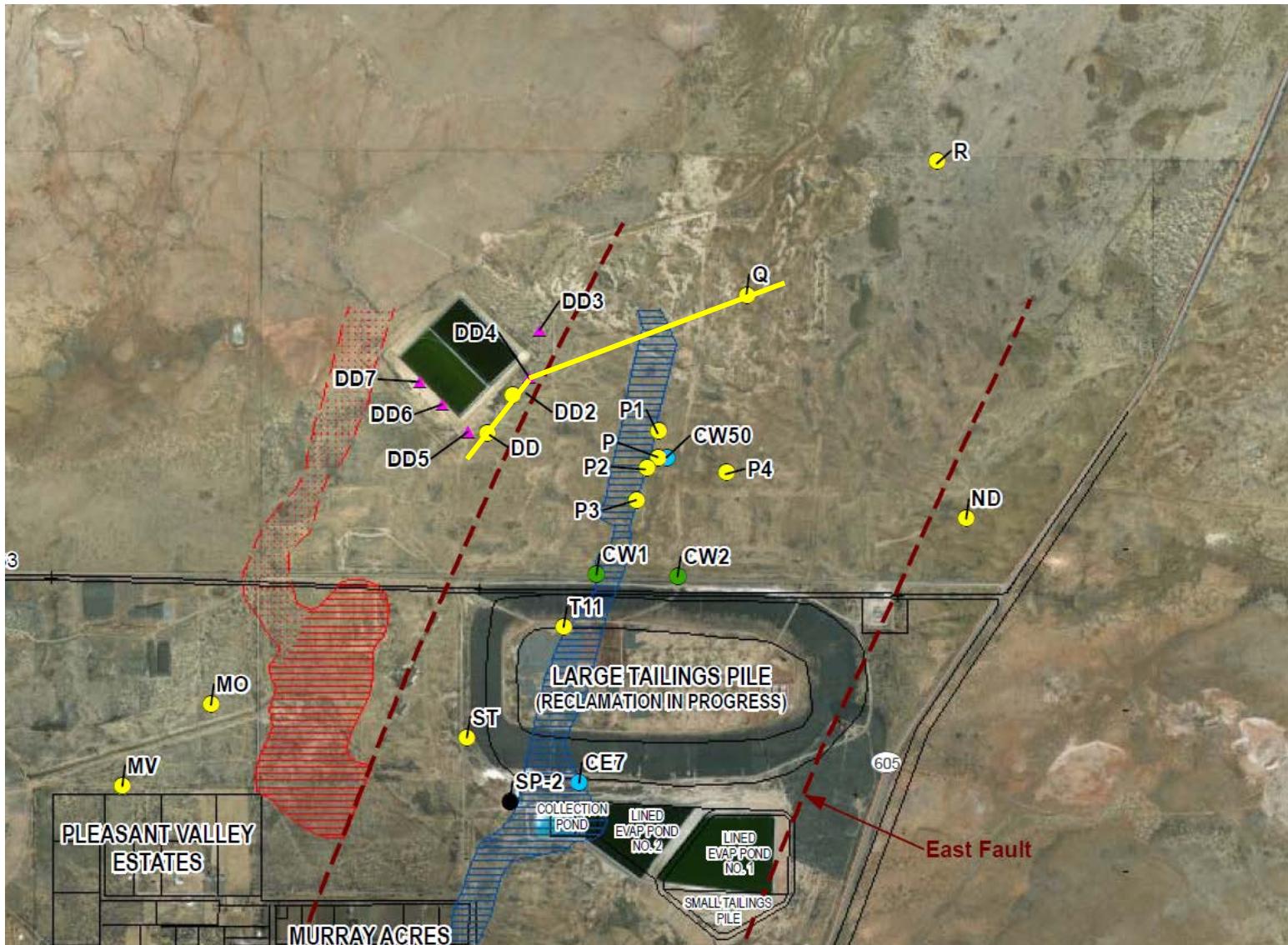
Notes

X – times magnified

Mineralogical conclusions

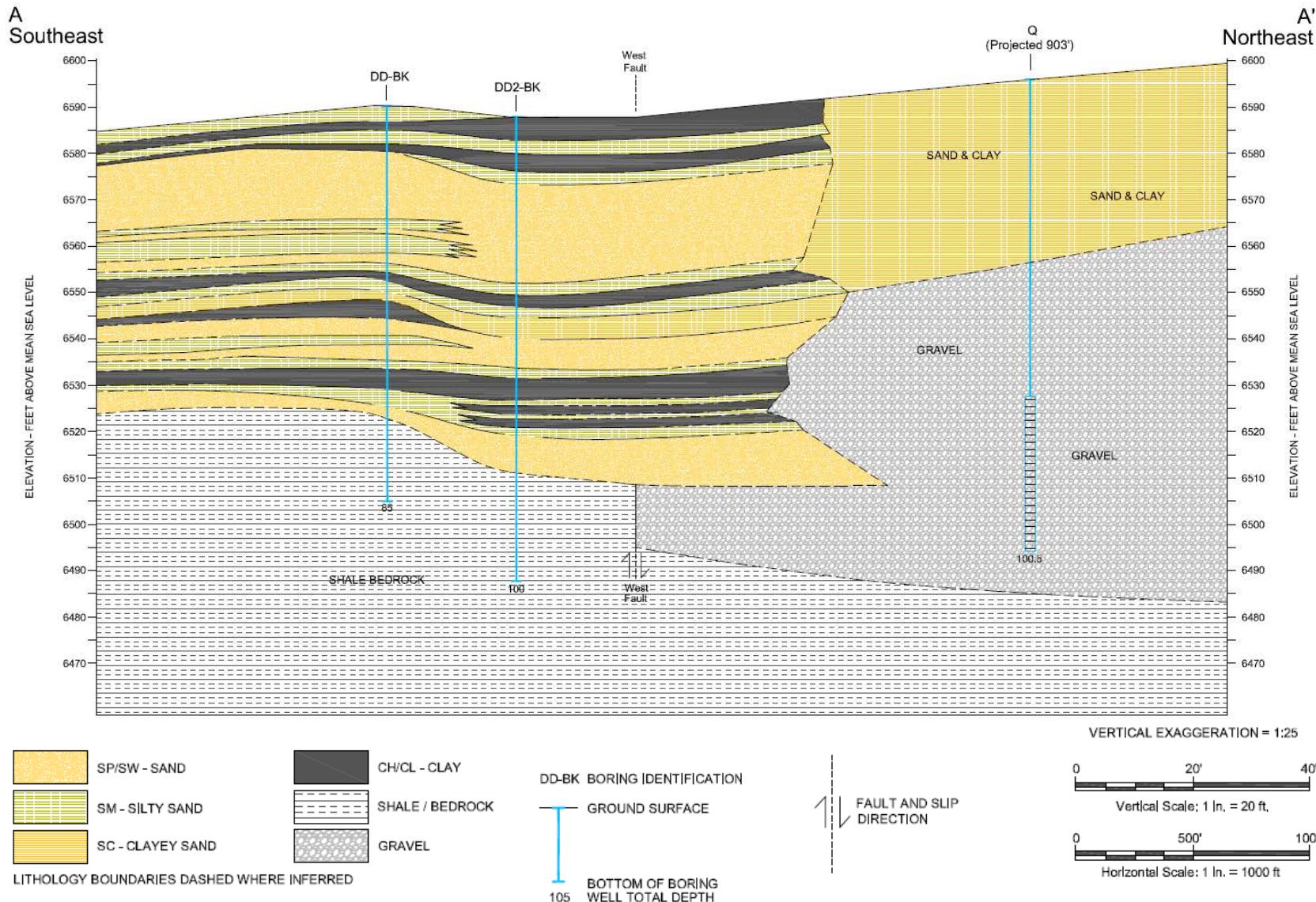
- Geochemically reduced and oxidized minerals are present, indicating heterogeneity in the mineralogical environment, microenvironments, and transitions from reducing to oxidizing conditions, affecting uranium mobility.
 - Pyrite pseudomorphs have been oxidized to iron oxides
 - Pyrite/pyrite pseudomorphs appear in saturated and unsaturated zones
 - The transition from a reduced environ to an oxidized one could liberate uranium by direct oxidation or through dissolution of uranium associated with pyrite
- Clays here have abundant organic carbon and may serve as a reservoir for reduced uranium, with diffusion of water and oxygen resulting in leaching of uranium
 - The clays here contain pyrite (iron), chalcopyrite (copper), galena (lead), sphalerite (zinc), which is important due to relative stability of pyrite
- Minerals present in the Morrison Fm are evident in the alluvial soils near DD/DD2, and morphologies observed indicate water-borne transport and deposition large distances from their origin
- The highest uranium was encountered in the unsaturated zone, indicating that uranium in alluvial deposits is naturally occurring due to transport and deposition of naturally uranium-rich materials over hundreds to thousands of years, not from deposition from uranium-bearing groundwater.

Cross section – Location

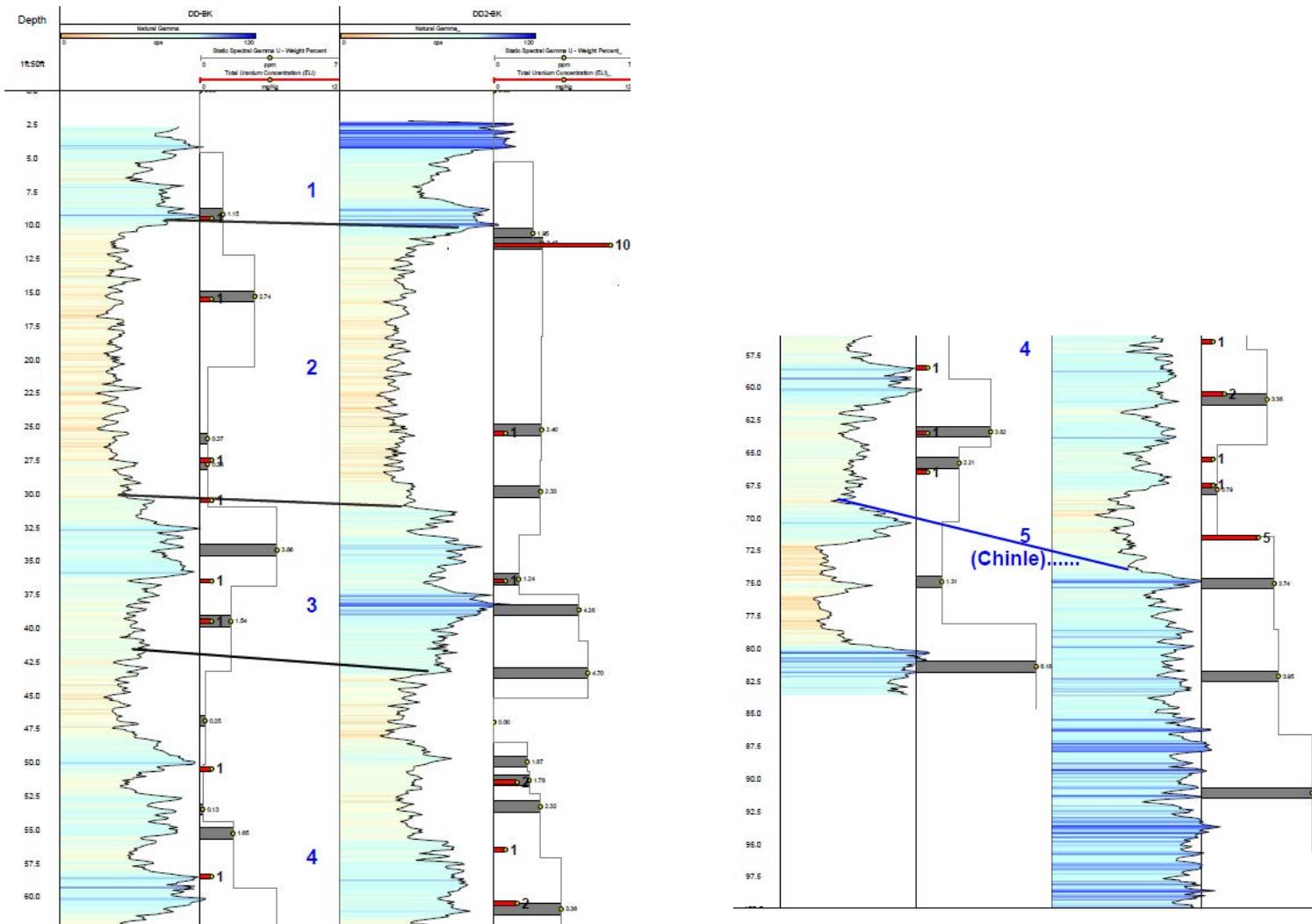


Cross section

New information in this area! Changes the overall interpretation of the DD/DD-2 area and is more consistent with depositional environment as presented by many geologists over last 100+ years



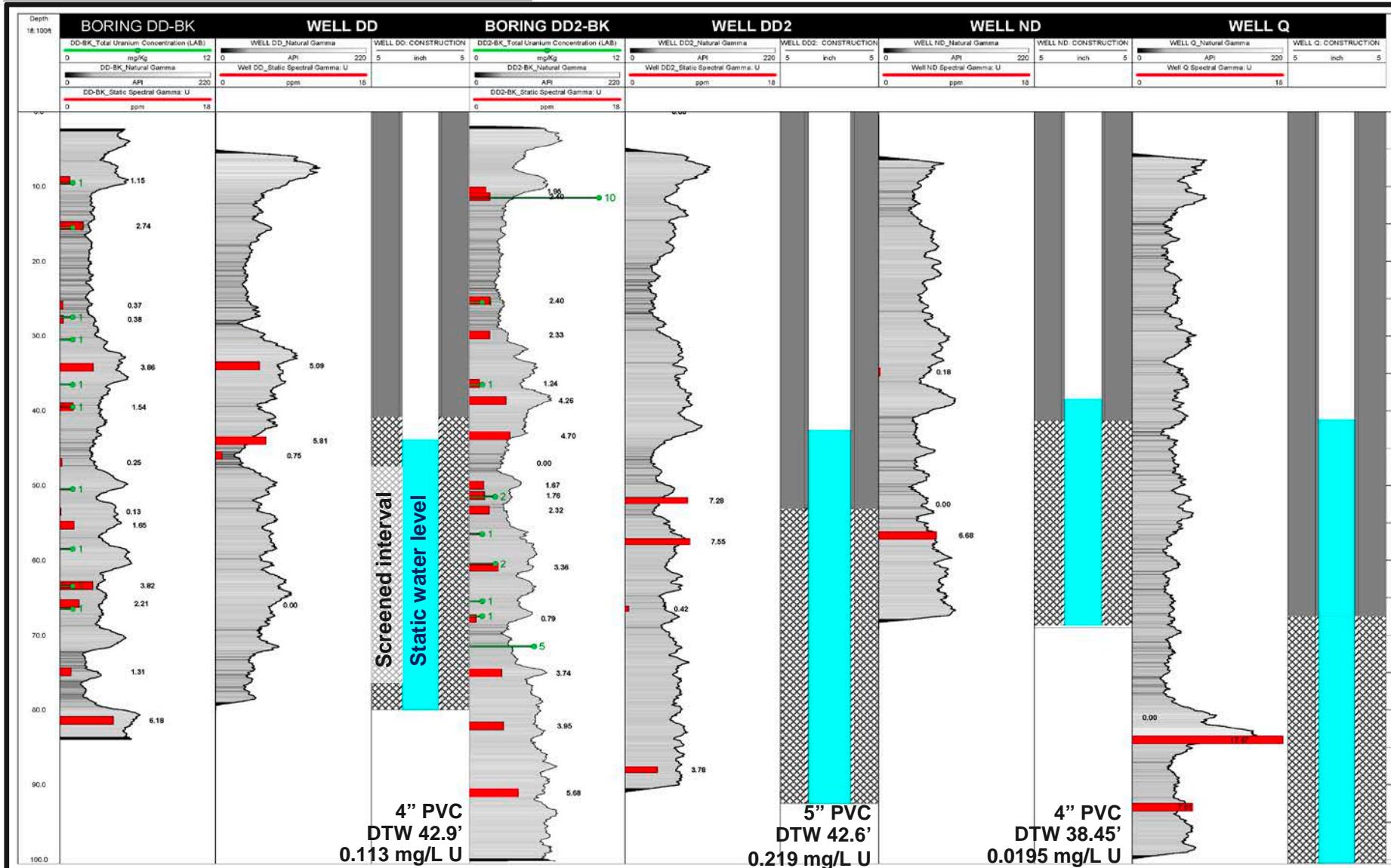
DD-BK and DD2-BK comparison natural gamma logs



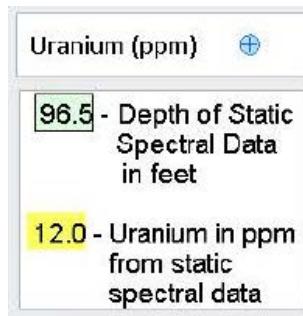
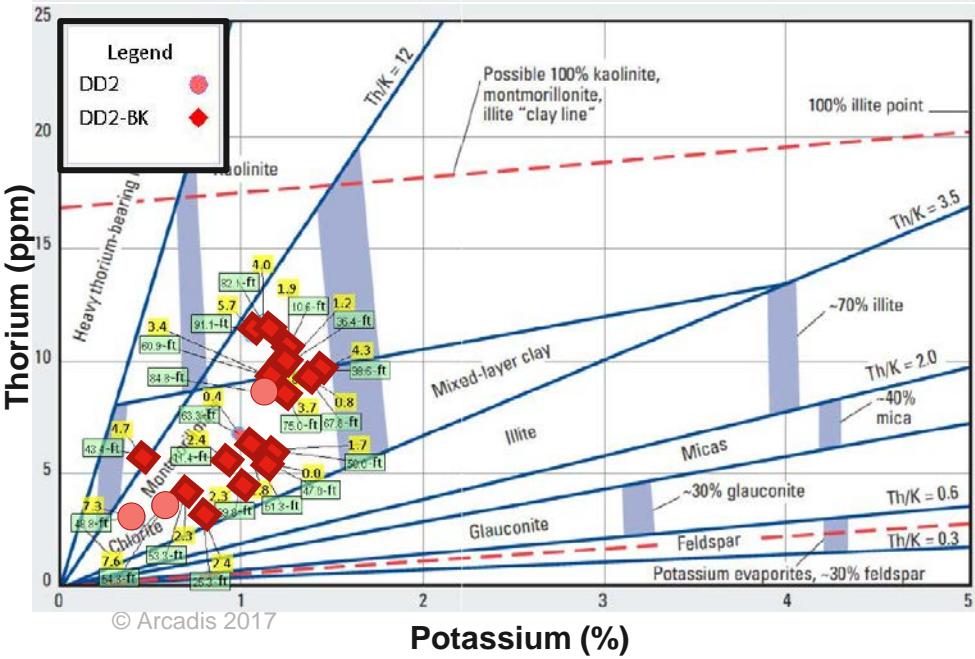
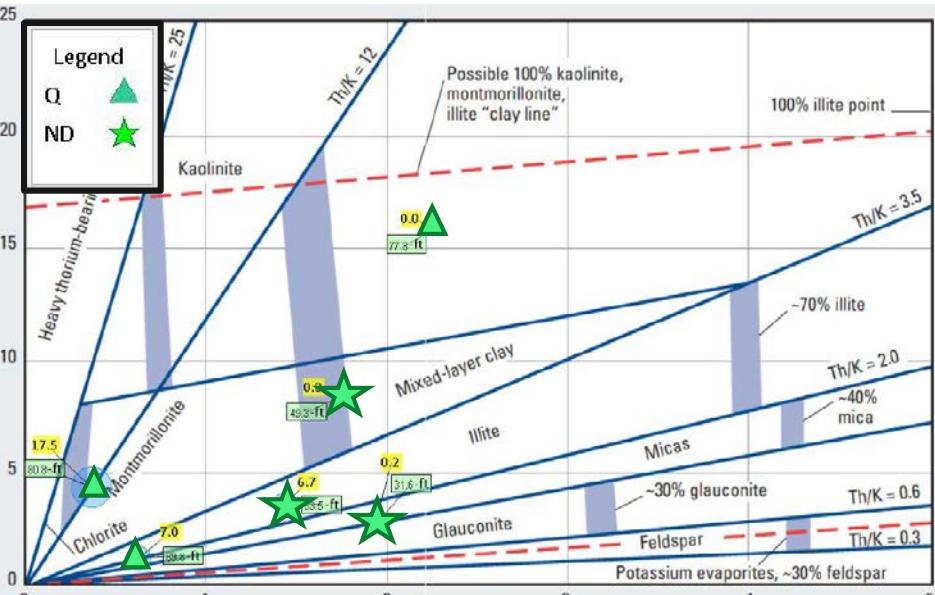
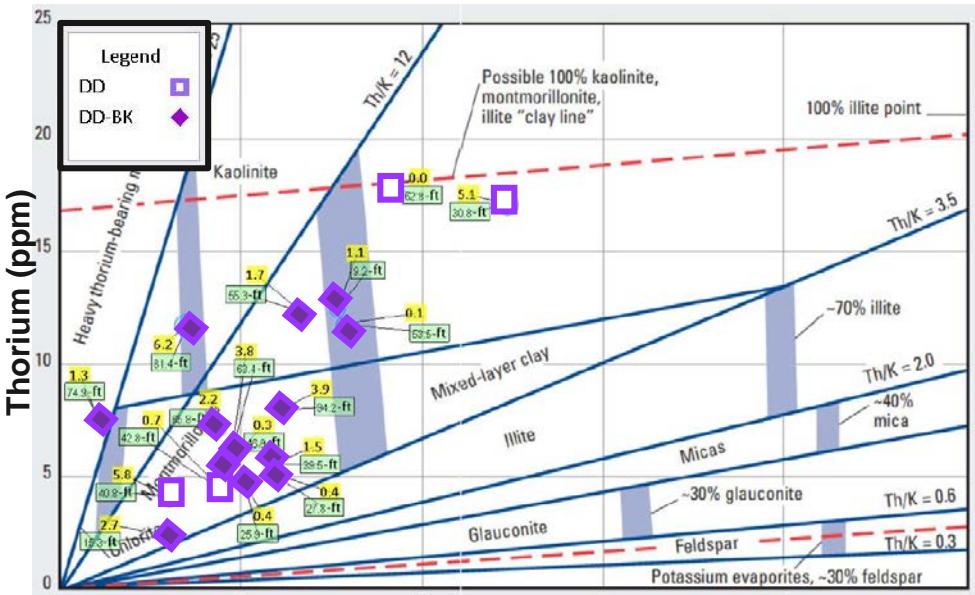
Alluvial uranium and well construction



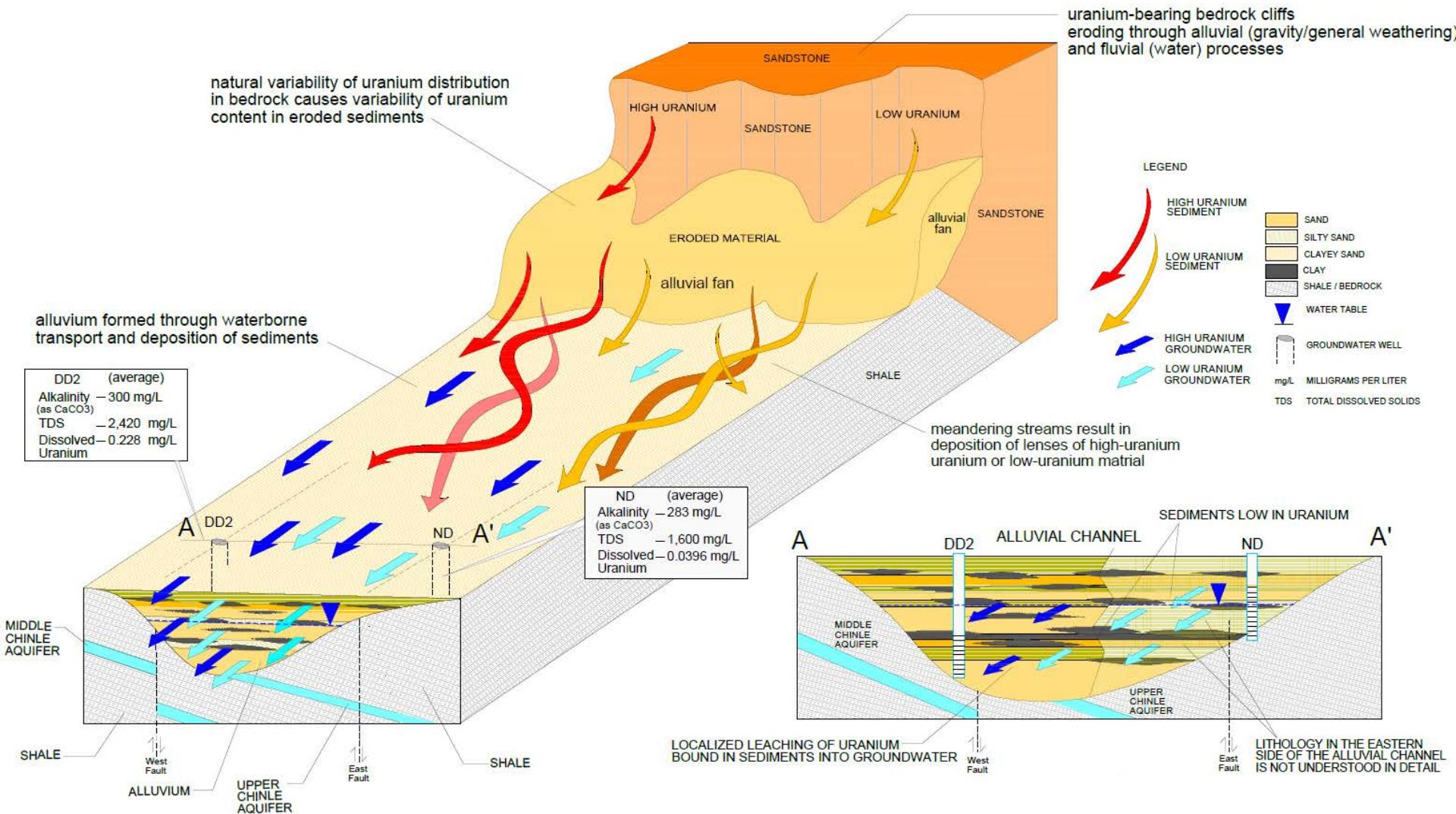
Uranium in alluvium is preferentially in fine grained sediments and varies significantly by location



Note: further refinement of these plots is currently in progress and updated plots will be released in future presentations/publications.



Potassium-thorium plots support different alluvial sediment origin from east to west



Potassium-thorium plots support different alluvial sediment origin from east to west